



**Atmospheric Surface Layer Characterization:
Preliminary Desert Lapse Rate Study
22–25 August 2000**

**Doyle S. Elliott, Gail Vaucher,
Jimmy Yarbrough, and David Quintis**

ARL-TR-2994

May 2003

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Army Research Laboratory

White Sands Missile Range, NM 88002-5501

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Computational & Information Sciences Directorate
Battlefield Environment Division
Boundary Layer Meteorology Branch**

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188		
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1. REPORT DATE (DD-MM-YYYY) May 2003		2. REPORT TYPE Final		3. DATES COVERED (From - To) August 2000-September 2002	
4. TITLE AND SUBTITLE Atmospheric Surface Layer Characterization: Preliminary Desert Lapse Rate Study 22-25 August 2000			5a. CONTRACT NUMBER		
			5b. GRANT NUMBER		
			5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S) Doyle S. Elliott Gail T. Vaucher Jimmy Yarbrough David Quintis			5d. PROJECT NUMBER		
			5e. TASK NUMBER		
			5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Research Laboratory Computational & Information Sciences Directorate Battlefield Environment Division ATTN: AMSRL-CI-EB White Sands Missile Range, NM 88002-5501			8. PERFORMING ORGANIZATION REPORT NUMBER ARL-TR-2994		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Laboratory 2800 Powder Mill Road Adelphi, MD 20783-1145			10. SPONSOR/MONITOR'S ACRONYM(S)		
			11. SPONSOR/MONITOR'S REPORT NUMBER(S) ARL-TR-2994		
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT <p>Results of the August 2000 Desert Lapse Rate (DLR) Experiment are presented. The DLR Experiment was performed to document the night-to-day transition effects on the desert Atmospheric Surface Layer (ASL). During the DLR Experiment, simultaneous 32 m and 2 m thermodynamic and wind data were gathered 2 hrs prior to, through 2 hrs after sunrise. Solar radiation data were also gathered over the Experimental Period. A GPS radiosonde was launched at the beginning of the atmospheric neutral event after sunrise to determine the depth of the isothermal layer. Lapse rate changes characterized the transition of the Night-Day lower-atmospheric Chihuahuan Desert conditions and are presented in the results.</p>					
15. SUBJECT TERMS atmospheric lapse rate, surface layer, neutral event, solar radiation, nocturnal-diurnal transition					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES 26	19a. NAME OF RESPONSIBLE PERSON Doyle S. Elliott
a. REPORT U	b. ABSTRACT U	c. THIS PAGE U			19b. TELEPHONE NUMBER (Include area code) 505-678-6509

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Acknowledgements

We would like to express appreciation for Mr. Fred Wilson of the White Sands Missile Range Meteorological Team and his assistance in loaning needed sensors to this effort. Additional thanks go to Mr. Alfred Gutierrez and SFC Deryck James for their assistance in executing the experiment.

Summary

Results of the August 2000 Desert Lapse Rate (DLR) Experiment are presented. The DLR Experiment was performed to document the night-to-day transition effects of the Atmospheric Surface Layer (ASL), and to support the Vaucher NE (Neutral Event) Prediction Model. During the DLR Experiment, simultaneous 32 m and 2 m thermodynamic and wind data were gathered 2 hrs prior to, through 2 hrs after sunrise. Solar radiation data were also gathered over the Experimental Period. A Global Positioning System radiosonde was launched at the beginning of the atmospheric NE after sunrise to determine the depth of the isothermal layer. Lapse rate (LR) changes characterized the transition of the Night-Day lower-atmospheric Chihuahuan Desert conditions, and are presented in the results, which indicated Night and Daytime data had less LR variability than the Twilight-through-NE data. The experiment, though generally successful, should be continued for a greater length of time and with a larger and more complete sensor array. The study is relevant to the U.S. Army's efforts, as the ASL transitional phenomena and periodicity affects those involved in Target Acquisition, Surveillance, and Chemical/Biological Transport and Diffusion.

1. Introduction

1.1 Project Name/Experiment

On 22–25 August 2000, the U.S. Army Research Laboratory conducted a Desert Lapse Rate (DLR) Experiment at the 100 ft Tower Site, White Sands Missile Range (WSMR), NM. This Experiment was also a feasibility study for a research project that focuses on forecasting the Atmospheric Neutral Events (NE) (Vaucher et al., 2002). A NE occurrence is defined, for our purposes, by a transitional neutral lapse rate in the Atmospheric Surface Layer (ASL); usually when the nocturnal surface inversion breaks down in transition to the unstable diurnal profile, or when the diurnal unstable profile cools in transition to the nocturnal stable layer (Stull, 2000, p. 72–74). To quote G.T. Vaucher, “The term *Neutral Event* or NE comes from the implied atmospheric stability being neither unstable nor stable. Later, these events were more correctly referred to as Surface Layer Stability Transitions or just Stability Transitions.” (Vaucher et al., 2002)

The NE is commonly associated with atmospheric refractivity and visibility factors. Atmospheric refractivity during the nocturnal-diurnal transition typically changes from abnormal-to-normal propagation, depending upon the severity of the nocturnal inversion layer’s lapse rate. Clear sky at night facilitates surface radiation, commonly leading to an ASL temperature inversion associated with a marked decrease of humidity with height (Battan, 1973). After sunrise, the surface warms to form a very thin superadiabatic layer over the first few centimeters above surface, and the morning inversion “erodes” from the surface upwards (Munn, 1966). The transition to the NE occurs more swiftly after the thin superadiabatic layer just above surface loosens surface “bubbles” of air, so that the layer from approximately 2 m to 200 m is warmed due to shear-driven entrainment (Angevine, 2001). From the perspective of radar propagation, the ASL affects propagation adversely when the nocturnal inversion is strong, and propagation returns to normal after the inversion breaks, during and after the NE (Battan, 1973). From the perspective of visibility, the lower atmosphere has less optical turbulence, evidenced by C_n^2 minima, during the NE transition (Vaucher, 1994). This transition typically lasts for a few minutes, when the ASL lapse rate becomes adiabatic, as opposed to the longer durations of the stable nocturnal (inversion) or unstable diurnal (superadiabatic) lapse rate in the ASL (Munn, 1966).

The DLR Test mission was to quantitatively characterize the lowest atmospheric layer in a desert environment by studying the lapse rate changes during the summertime night-to-day transition period. For specific information on the experimental plan and method, refer to Appendix A. While the dataset for this experiment specifically indicates local, seasonally pertinent trends peculiar to the experiment site, broader inferences could be made when more data are available for analysis. Three cases of data are presented: 22, 23 and 25 August 2000. The analysis begins with a review of the cases’ large-scale atmospheric conditions, and continues with a decrease in the resolution of the observations until a review of the actual data collected is presented. The discussion of actual data is presented in three temporal subsets: nighttime, sunrise-to-NE, and daytime.

1.2 Methods

The arid Test site had the Organ mountains (closest were approximately 3 miles) to the west and southwest that rose about 1500 m above the 1213 m (Mean Sea Level) desert location.

Meteorological (Met) sensors were mounted on a 100 ft wooden tower at the 35 m and 2 m levels. Three radiosonde launches per day were executed within 80 m of the tower. These launches were targeted for 0500 Mountain Daylight Time (MDT), NE (~0735 MDT), and 0900 MDT. Surface observations were taken at each radiosonde launch and at hourly intervals.

2. Met Sensors Used

T-RH sensors at 2 m and 35 m were Vaisala model HMP35AC probes with solar radiation shields. The wind was monitored at 35 m by an R.M. Young 05103 wind monitor, and at surface by the ML-433/PM anemometer. The solar pyranometer used was the Weathertronics model 3020, which was mounted at the 35 m level.

2.1 Upper Air Equipment Used

The Vaisala MW12 rawinsonde set was used with Vaisala RS80-15G radiosondes. Balloons used were 800g (mfr. Totex) for the 0500 MDT release, and 200g Totex balloons for the other releases. Each radiosonde was simultaneously tracked by our MW12 and by the WSMR Met Team's Global Positioning System-upgraded Vaisala Digicora MW11.

3. Results and Discussion

3.1 Case I: 22 August 2000

On 22 August, 2000, a dry subsiding air mass around the southern side of a subtropical high pressure system gave WSMR, NM stable conditions characterized by clear to partly cloudy skies, light winds, and temperatures near the seasonal averages (WSMR Forecast Website, 2000). The nocturnal drainage flow from the Organ Mountains caused light, predominantly northwesterly winds until the southeasterly diurnal regime took over approximately 2 hours after sunrise. Local sunrise (SRL) occurred at 0638 MDT (USNO Website, 2000).

3.1.1 Nighttime

During the pre-dawn data collection, drainage flow from the Organ Mountains continued consistently with only a few brief lulls throughout this nocturnal period. As the twilight brightened the horizon, the wind shifted from northwest to easterly and decreased in velocity with more lulls. Data from Appendix B, figures B1 and B2, indicated the following summary observations for the period: The 35 m level minus 2 m level Temperature difference (Delta-T) for the period 0415–0545 MDT remained between 2.5 °C and 3.1 °C, averaging 2.7 °C. The average 2 m–35 m lapse rate (LR) was +76.0 °C/km for the same period. The Delta-T average

from 0415–0629 MDT was 2.8 °C. Just prior to dawn, the Delta-T increased to 3.4 °C. The 0510 MDT radiosonde revealed the inversion depth to be about 40 m, and ran from a surface temperature of 20.9 °C to 23.1 °C at the top of the inversion. The LR for this inversion was +55.0 °C/km; and from the top of the inversion to 4.725 km Above Ground Level, the LR was a more typical desert LR of –7.0 °C/km.

3.1.2 Sunrise through NE

The solar radiation sensor indicated no increase in solar radiation until approximately 0629 MDT. The average Delta-T from 0629–0638 MDT was 3.2 °C. Nighttime sky conditions (0510 MDT) were clear. By 0650 MDT, a thin cirrus band was visible on the eastern horizon and 1/10 stratocumulus was noted to the west.

The neutral event (NE) data collection was comprised of the data collected between SRL and 0845 MDT. This period was characterized by very light winds, which became slightly stronger and southeasterly after 0840 MDT when diurnal warming allowed coupling of the lowest layers. Fair skies and seasonal temperatures prevailed. The 35 m wind speed dropped to zero at 0650 MDT, and for the span of 0650–0708 MDT, the wind speed averaged 0.5 m/s. During this period, the Delta-T began to decrease (from 3.9 °C to 2.9 °C) due to surface warming and stable 35 m temperatures. The 35 m temperature varied by only 0.3 °C, while the 2 m temperature rose 0.7 °C. From 0650 MDT until the NE at 0755, the Delta-T decreased from 3.9 °C to zero, an average decrease of .06 °C/min. A false NE was recorded between 0830 and 0845 MDT, which was due to a lull combined with solar heating of the roof area of the tower where the 35 m sensors were placed. The slope of solar radiation versus time reached a near maximum and remained nearly linear from 0730–0845 MDT. Solar radiation at 0730 measured 98.5 W/m², and at 0845 MDT measured 362.2 W/m². Solar heating at the surface began to effect an increase in the 2 m temperature at 0654 MDT, and from 0700 MDT until the NE there was an increase of 4.5 °C. The 0735 MDT radiosonde revealed a –14.3 °C LR from 0–49 m, where the surface temperature was 22.5 °C and the 49 m temperature was 21.8 °C. The next data point at 83 m was 22.5 °C, yielding a zero lapse from surface. The LR from the top of the inversion to 4.715 km AGL was –6.5 °C/km, or 0.44 °C/km less than the 0510 MDT ascension indicated. The sun angle at NE was somewhat higher in this case than that of the other two cases presented (see appendix C), since the NE timing was evidently affected by the cirrus veiling the sun's disk in the east just after sunrise, and by clear nighttime conditions allowing the soil surface to cool radiatively. The temperature traces from about 0740 MDT may be peculiarly affected by a lull during that period, which may have caused the timing of the NE to be reported later due to an artifact of equipment thermal differences between the tower top and 2 m setup. This apparent artifact during lulls is seen again after NE, as false NE caused by the unequal temperature increase at the 35 m level due to the rooftop's thermal properties versus those of the ground's.

3.1.3 Daytime (Late Morning)

The subsequent diurnal data spanned 0845–0959 MDT. For that period, the sky condition continued to be fair, and slightly stronger southeasterly breezes began in contrast to the earlier period of northwesterlys. The slopes of both the 2 m and 35 m temperature trends became approximately equal between 0845–0959 MDT. Note that two false NE's were recorded at 0915 and 0942 MDT, both when the wind fell to near-zero velocity briefly and allowed the thermal properties of the tower roof area to affect the temperature sensor mounted there. The sky

condition at 0920 had 2/10 cirrus west and north, but clear overhead. The solar time series data continued to be nearly linear during 0845–0912 MDT (an average $3.5 \text{ W/m}^2/\text{min}$ increase for the period). The slope decreased during 0912–0959 MDT to an average $3.0 \text{ W/m}^2/\text{min}$ increase. The 0920 MDT radiosonde data indicated a super-adiabatic layer off surface to 40 m (LR = $-112.8 \text{ }^\circ\text{C/km}$), which the tower data reported at $-13.7 \text{ }^\circ\text{C/km}$. The vast difference may be attributed to the fact that the surface temperature for the balloon was collected at 1 m instead of 2 m, and that the radiosonde sensors do not have the same degree of precision as the fixed tower Temperature-Relative Humidity (T-RH) probe. Errors in lapse rate are also magnified as the scale of the measurements decreases, i.e., the error in a 50 m vertical layer appears to have 20 times the magnitude than the same amount of error between two data points that are 1 km apart vertically.

3.2 Case II: 23 August 2000

On 23 August, 2000, southeasterly monsoonal flow circulating around a high-pressure ridge brought moisture mainly to Arizona, Utah, and western New Mexico, and to a lesser extent to WSMR (WSMR Forecast Website, 2000). Early morning sky conditions featured altocumulus and cirrus moving westerly over WSMR and orographic stratocumulus hung above the mountains.

3.2.1 Nighttime

The pre-dawn conditions were characterized by light and variable winds at the surface, a slowly rising barometer, and seasonal temperatures. The Delta-T averaged $2.7 \text{ }^\circ\text{C}$ between 0415–0638 MDT. When the 35 m winds changed from northerly to southwesterly between 0545–0550 MDT, the 35 m temperature dropped approximately $1.5 \text{ }^\circ\text{C}$ in three minutes, an effect that could possibly be attributed to drainage flow from the Organ Mountains. The 0456 MDT radiosonde data revealed a strong but shallow inversion of $4.6 \text{ }^\circ\text{C}$ from surface to 60 m AGL, a LR of $+76.7 \text{ }^\circ\text{C/km}$. The LR from the top of the inversion to 3407 m averaged $-7.1 \text{ }^\circ\text{C/km}$. The solar radiation data revealed no increase in radiation until 0623 MDT. The Delta-T average from 0415 to 0638 MDT was $3.6 \text{ }^\circ\text{C}$, and the average LR then was $+103.4 \text{ }^\circ\text{C/km}$.

3.2.2 Sunrise through NE

The NE occurred at 0735 MDT. The NE data were comprised of the collection between SRL (0638 MDT), and 0845 MDT. At SRL, thin cirrus were observed above the eastern horizon, and 1/10 altocumulus were overhead moving westward. This case exhibited the earliest NE of the three cases (see sun angle data, Appendix C). The wind was northeasterly at 2–4 m/s, becoming easterly, then southeasterly and decreasing to southerly at 2 m/s at the NE. The 35 m temperature remained relatively stable for the period, increasing only $1 \text{ }^\circ\text{C}$ from 0638–0800 MDT. The 2 m temperature, however, rose nearly $6.9 \text{ }^\circ\text{C}$ in the same period. From 0638–0735 MDT the 2 m temperature rose $5.2 \text{ }^\circ\text{C}$, and the minimum occurred at 0640 MDT. The LR maximum was $+130.8 \text{ }^\circ\text{C/km}$ at 0643 MDT. The Delta-T decreased by an average $.08 \text{ }^\circ\text{C/minute}$ from 0640–0735(NE). The warming at 2 m appeared to coincide with a decrease in the east wind component and an increase in the south wind component from approximately 0700–0730 MDT. Solar radiation at 0730 measured 120.0 W/m^2 and at 0845 measured 383.4 W/m^2 . The solar radiation time series was nearly linear from 0730–0845 MDT, with small

variances after NE due to thin clouds passing. Solar heating at the surface began to effect an increase in the 2 m temperature at 0644 MDT, and from 0700 MDT until the NE there was an increase of 4.7 °C.

The sky at the 0730 MDT radiosonde launch was clear overhead, with few thin cirrus east, and a few stratocumulus over the mountains west were dissipating. The sunlight was unobstructed by clouds at the tower site. Surface was calm. The surface temperature at launch was 21.2 °C, Relative Humidity was 45%, and pressure 885.8 mb. For complete tower data, refer to Appendix B. The temperature profile near surface indicated a 0.6 °C inversion at 55 m, where the LR was +10.9 °C/km. From the top at 55 m to 4.75 km AGL, the LR averaged -6.0 °C/km. There was an isothermal layer centered at 2 km AGL.

3.2.3 Daytime (Late Morning)

The diurnal data from 0845–0953 MDT showed similar tower-temperature time-series slopes to that of 22 August. The Delta-T averaged -0.8 °C, and the average LR was a super-adiabatic -23.1 °C/km. This period saw a decrease in 35 m wind velocity until the end of the collection period at 0951 MDT, when there was a 5 m/s gust. There were false NE's during brief lulls.

The 0856 MDT radiosonde was launched under clear skies, 25.0 °C surface temperature, wind 2m/s from 45°, and pressure 886.6 mb. The data indicated a super-adiabatic layer of 3.3 °C from surface to 66 m, for a LR of -50.0 °C/km. The tower data indicated a LR of -22.0 °C/km for that time.

3.3 Case III: 25August 2000

On 25 August, 2000, an upper ridge overhead and to the east continued to suppress convection (WSMR Forecast Website, 2000). The sky condition was mostly sunny with patches of altocumulus and cirrus. Temperatures were near seasonal, and winds were light and northwesterly. Data from Appendix B, figures B5 and B6, indicated the nocturnal drainage flow was consistently from the northwest with few lulls, and averaged 3.1 m/s from 0430–0600 MDT. Clouds on the horizon obscured SRL.

3.3.1 Nighttime

The pre-dawn data collection was characterized by the consistent drainage flow and by the decrease in wind velocity between 0600–0639 MDT. Data from Appendix B, figures B5 and B6, indicated the following: The average wind velocity for the period was 0.9 m/s, a contrast with the period 0430–0600 MDT, where the average was 3.1 m/s. The temperatures from 0430–0600 MDT ran from 21.0 °C to 21.6 °C at 35 m, and from 18.6 °C to 19.4 °C at 2 m. From 0600–0639 MDT, the temperatures decreased from 21.6 to 19.7 °C at 35 m, and from 18.6 °C to 17.0 °C at 2 m. The Delta-T averaged from 0431–0639 MDT was 2.2 °C, and the average LR was +87.7 °C/km.

The 0501 MDT radiosonde revealed an inversion from 0–72m AGL, and an isothermal layer from 72 m–267 m. The 2 m temperature was 18.9 °C, the 34 m temperature was 23.8 °C, and the 72 m temperature and 115 m temperature were 24.4 °C. The LR from 0–72m was +76.3 °C/km (tower LR was +101.5), and from 267 m to 3744 m the LR averaged -7.5 °C/km. The winds were northerly from 0–1 km, and southerly from 1–5 km (AGL).

3.3.2 Sunrise through NE

The data segment including the NE conditions spanned 0639–0900 MDT. The NE occurred at 0751 MDT. The period was characterized by a consistent decrease in wind velocity from 0720–0800 MDT, and cloud cover, up to 4/10 altocumulus, affected solar radiation. After NE, until 0900 MDT, the winds remained very light, in contrast to the first two days of data.

The 0748 MDT radiosonde data recorded a 1.2 °C inversion from 0–324m, LR = 3.7 °C/km. The 0–93 m layer was nearly isothermal (21.4 °C at 0 m, 21.3 °C at 40 m, and 21.5 °C at 93 m). The LR from 324–3754 m AGL averaged –7.0 °C/km. The 0748 MDT tower LR was +8.5 °C/km.

3.3.3 Daytime

No daytime data were taken for this period, as the experiment was forced to terminate due to range mission requirements.

4. Conclusions

The Night and Daytime data showed less LR variability than the Twilight-through-NE data. The Max LR occurred after SR on 22 August, just before SRL on 23 August, and at night on 25 August. The first two Test days reported a maximum wind within 1 hour after SRL; and 25 August showed the wind max occurring at night. A thin veil of cirrus hovering over the eastern horizon impacted the NE timing by delaying the NE. The presence of the clouds was easily noted in the solar radiation plots, especially on 25 August. While the Delta-T on 23 August was the greatest of the 3 cases, the NE for that case occurred significantly earlier than the other two cases. Wind velocity peaked and shifted during this case between SRL and NE. Perhaps the more rapid occurrence of the NE was a function of the atmospheric mixing implied in the increased wind velocity.

5. Recommendations

The experiment, though generally successful, should be continued on a larger scale both temporally and spatially, i.e., the next experiment should be continued for a greater length of time and with a larger and more complete sensor array. It is recommended that at least three instrument towers be fitted with wind heads, T-RH sensors, soil temperature sensors, solar-tracking pyranometers, scintillometers, and total-sky imagers. Sub-experiments using this instrument tower array should be conducted seasonally to document seasonal effects of solar radiation on the desert environment lapse rate changes. The benefit of these data to the improvement of the Vaucher NE Prediction Model would be amplified by the use of a database. The prediction of both the occurrence and duration of the NE could be of benefit in decision-aid technology.

6. References

- Angevine, Wayne M.; Baltink, H.K.; Bosveld, F.C. Observations of the Morning Transition of the Convective Boundary Layer. *Boundary-Layer Meteorology* **2001**, 101, 209–227.
- Battan, Louis. *Radar Observation of the Atmosphere*; University of Chicago Press: Chicago, 1973.
- COMPASS version 1.2 (freeware).
- Elliott, Doyle S.; Vaucher, G.T. *Desert Lapse Rate Experiment, Test Plan and Method*, Internal Document; U.S. Army Research Laboratory: White Sands Missile Range, NM, 2000.
- Forecast for White Sands Missile Range. <http://weather.wsmr.army.mil/public/fcst.txt> (accessed 22–25 August, 2000).
- Munn, R.E., ed. Descriptive Micrometeorology. Supplement 1 to *Advances in Geophysics*. Academic Press: New York, 1966.
- Stull, Roland B. *Meteorology for Scientists and Engineers*, 2nd ed.; Brooks/Cole: Pacific Grove, CA, 2000.
- Vaucher, Gail-Tirrell; Endlich, Robert. *Forecasting/Modeling the Atmospheric Optical Turbulence Neutral Events over a Desert Environment*, Proceedings of the 1994 Battlefield Atmospheric Conference, U.S. Army Research Lab, White Sands Missile Range, NM, Nov 29-Dec 1, 1994.
- Vaucher, Gail-Tirrell; Raby, John. *Exploiting Environmental Conditions: Atmospheric Stability Transition Forecasting*, Proceedings of the 23rd Army Science Conference, Orlando, FL, 2002 Dec 2-5, 2002. White Sands, New Mexico Rise and Set for the Sun. <http://weather.wsmr.army.mil/textdata/srss.txt> (accessed 20 August, 2000).

Appendix A - Project Plan/Method/Schedule (Case listing)

DESERT LAPSE RATE EXPERIMENT

[Subset of 00 Aug - Mobilizing Local Meteorological Profile Module Test]

(Last Rev: 00 June 29, Elliott/Vaucher)

DESERT LAPSE RATE EXPERIMENT MISSION OBJECTIVE: To quantitatively characterize the lowest atmospheric layer in a desert environment, by studying the lapse rate changes (atmospheric stability) during the summertime night to day transition period.

DESERT LAPSE RATE EXPERIMENT PLAN:

Part I: Assemble and test two surface sensors and a solar radiation instrument in a controlled environment.

Part II: Install and test sensors at the Thompson 100 Ft Tower Site.

Part III: Run Desert Lapse Rate Experiment at the Thompson 100 Ft Tower Site.

Part IV: Analyze and publish results.

DESERT LAPSE RATE EXPERIMENT METHOD:

Part I: PreTest (Completion target date: 7-14-00).

- (1) Assemble two surface sensor instrument systems in a controlled environment.
- (2) Run side-by-side Pre-Tests to establish precision of two sensor units.
- (3) Develop software to simultaneously report (and compare?) data from sensor units.
- (4) Assemble Pyranometer and develop software to acquire data.

Part II: PreTest (Completion target date: 8-11-00).

- (1) Install sensor unit onto 32m level of Thompson Site Tower with solar radiation instrument.
- (2) Install 2m level sensor unit.
- (3) Simultaneously collect thermodynamic and wind data at the 32m and 2m levels at the Thompson Site 100 Ft Tower.
- (4) Run sample test to calculate Delta-T and Atmospheric Lapse Rate.
- (5) Setup and test functionality of rawinsonde system.

Part III: Test (Completion target date: 8-25-00).

- (1) Simultaneously collect thermodynamic/wind data at the 32m and 2m levels at the Thompson Site 100 Ft tower, over a time span of Sunrise plus and minus 2 hours.
- (2) Launch rawinsonde data during the Atmospheric Neutral Event.
- (3) Calculate atmospheric lapse rate and plot a timeseries of values.
- (4) To compare measurements with the rawinsonde data.

Part IV: Post-Test (Completion target date: 12-14-00).

- (1) Analyze plots generated.
- (2) Publish results (AMS paper and/or Technical Report).

Test Plan/Method/Schedule Reviewed by:

<u>Initial</u>	<u>Date</u>	<u>Team Member</u>	<u>Initial</u>	<u>Date</u>	<u>Team Member</u>
_____	_____	Elliott	_____	_____	Yarbrough
_____	_____	Quintis	_____	_____	Vaucher

00 AUG - MOBILIZING LOCAL METEOROLOGICAL PROFILE MODULE TEST

TEST SCHEDULE: [00 Aug 22-25]

(Last Rev: 00 Aug 21, Vaucher)

To better coordinate the LMPM Test, the following is a schedule of events for each day.

PRE-TEST

16 Aug **100 Ft Tower, Install High Speed Trailer.**

TEST:

21 Aug, Monday **0800-1200, Bldg 19472, Install hardware into HMMWV.**
 0900-1000: MPSMAIN (Yarbrough, Quintis)
 1000-1030: Marwin (Yarbrough, Elliott)
1100-1245, Transport equipt to 100 Ft Tower, Setup all Equipment.
1247 100 Ft Tower, DATA COLLECTION [C-station/ARL RAOB Launch].
1400-COB 100 Ft Tower/Bldg 1622, Finish Sfc sensor install/Misc action items.

22 Aug, Tuesday **0400 Bldg 1622, Leave for site from back door.**
0415-0500, 100 Ft Tower, Pre-Test checkout of individual systems, Raob Prep.
0500-0600, 100 Ft Tower, DATA COLLECTION, Raob Launch.
0600-0630, 100 Ft Tower, Data Transfer, Plots generated and printed.
0630-0700, 100 Ft Tower, Raob preparation: Slow ascent rate.
0700-0800, 100 Ft Tower, DATA COLLECTION, Raob Launch.
0800-0830, 100 Ft Tower, Data Transfer, Plots generated and printed.
0830-0900, 100 Ft Tower, Raob preparation.
0900-1000, 100 Ft Tower, DATA COLLECTION, Raob Launch.
1000-1030, 100 Ft Tower, Data Transfer, Plots generated and printed.
1030-1100, 100 Ft Tower, ALL-HANDS Mtg to update next day action items.
1100-1300, Bldg 1622, Post-Test Analysis, Normal Day activity.

23 Aug, Wednesday **0400-0500, 100 Ft Tower, Pre-Test checkout of individual systems, Raob Prep.**
0500-0600, 100 Ft Tower, DATA COLLECTION, Raob Launch.
0600-0630, 100 Ft Tower, Data Transfer, Plots generated and printed.
0630-0700, 100 Ft Tower, Raob preparation: Slow ascent rate.
0700-0800, 100 Ft Tower, DATA COLLECTION, Raob Launch.
0800-0830, 100 Ft Tower, Data Transfer, Plots generated and printed.
0830-0900, 100 Ft Tower, Raob preparation.
0900-1000, 100 Ft Tower, DATA COLLECTION, Raob Launch.
1000-1030, 100 Ft Tower, Data Transfer, Plots generated and printed.
1030-1200, Bldg 1622, BMMT(Modeling Team) Annual Branch/Div Review.
1200-1230, Bldg 1622, ALL-HANDS Mtg to update next day action items.

24 Aug, Thursday 'Down day' due to Range mission.

25 Aug, Friday 0400-0500, 100 Ft Tower, Pre-Test checkout of individual systems, Raob Prep.
0500-0600, 100 Ft Tower, DATA COLLECTION, Raob Launch.
0600-0630, 100 Ft Tower, Data Transfer, Plots generated and printed.
0630-0700, 100 Ft Tower, Raob preparation: Slow ascent rate.
0700-0800, 100 Ft Tower, DATA COLLECTION, Raob Launch.
0800-0830, 100 Ft Tower, Data Transfer, Plots generated and printed.
0830-0900, 100 Ft Tower, Raob preparation.
0900-1000, 100 Ft Tower, DATA COLLECTION, Raob Launch.
1000-1030, 100 Ft Tower, Data Transfer, Plots generated and printed.
1030-1100, 100 Ft Tower, ALL-HANDS Mtg.
1100-1230, 100 ft Tower/Bldg 19472, Pack-up gear/Transport to Bldg 19472.
1230-1300, Bldg 19472, Off-load gear.

INTERNAL PROJECT REVIEW (IPR): EACH POC REPORT EVALUATION of their piece.

28 Aug, Monday 0800-0900, Bldg 1622, Prepare IPR questions:

1. Improvements done since 00 May Test.
2. Lessons learned from this LMPM Test.
3. Action Items needing to be addressed & suggested POC.
4. Constructive comments/suggestions.

0900-1100, Bldg 19472, ALL-HANDS Meeting.

_____ Creegan	_____ Gutierrez
_____ Elliott	_____ Quintis
_____ Jameson	_____ James
_____ Yee	_____ Measure
_____ Vaucher (Last Reviewer)	_____ Brown

IPR: 00 Aug-Mobilizing LMPM Test
(00 Aug 22-25)

Name: _____ **Date:** _____
Sub-Experiment Title: _____
POC for: _____

- 1. Improvements done since 00 May LMPM Test.**

- 2. Lessons learned from this LMPM Test.**

- 3. Action Items needing to be addressed and a suggested POC for each Action Item.**

- 4. Constructive comments/suggestions.**

Appendix B - Sensor Data Plots by Cases

Case 1

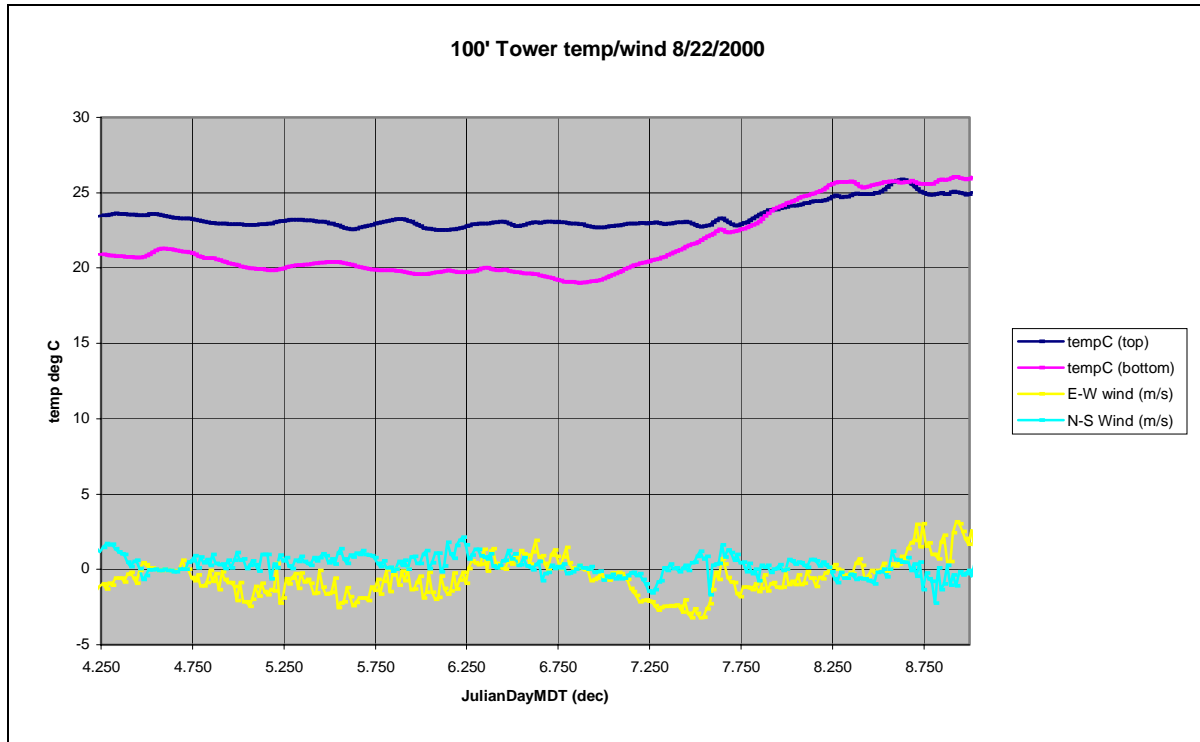


Figure B1. Tower temperature versus wind, 8/22/2000.

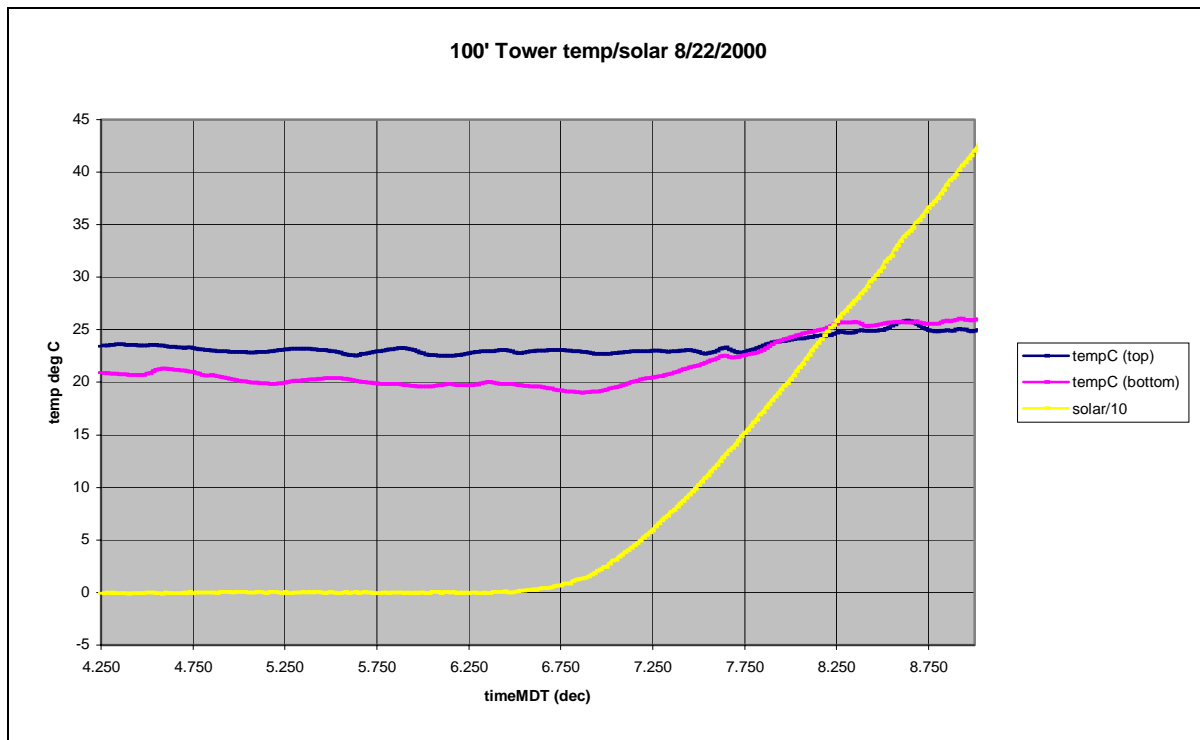


Figure B2. Tower temperature versus solar radiation, 08/22/2000.

Case 2

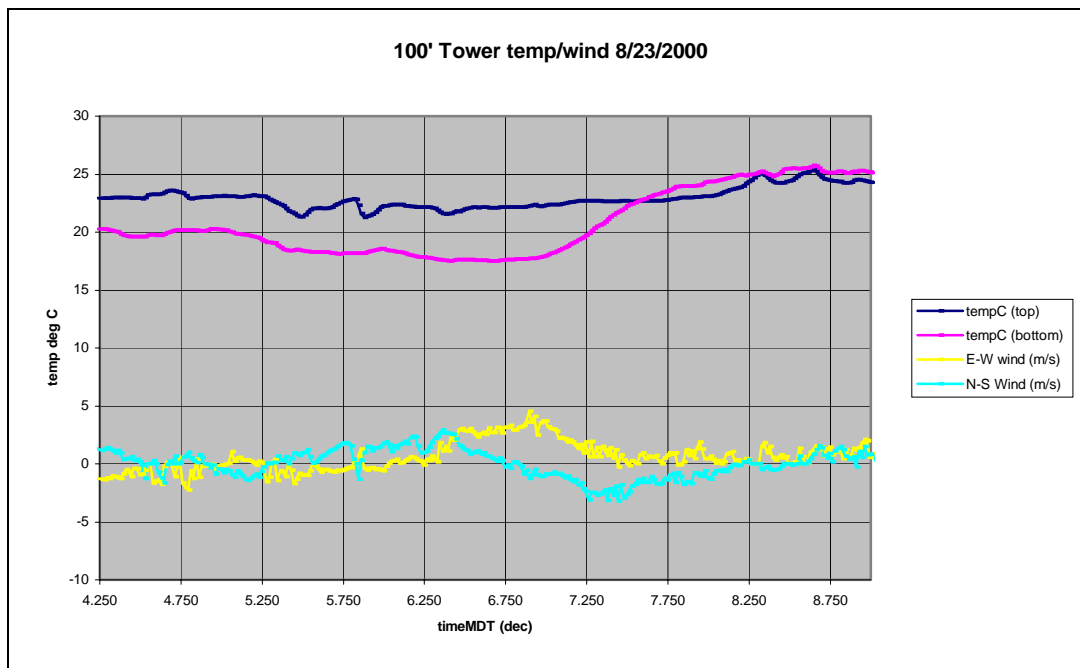


Figure B3. Tower temperature versus wind, 08/23/2000.

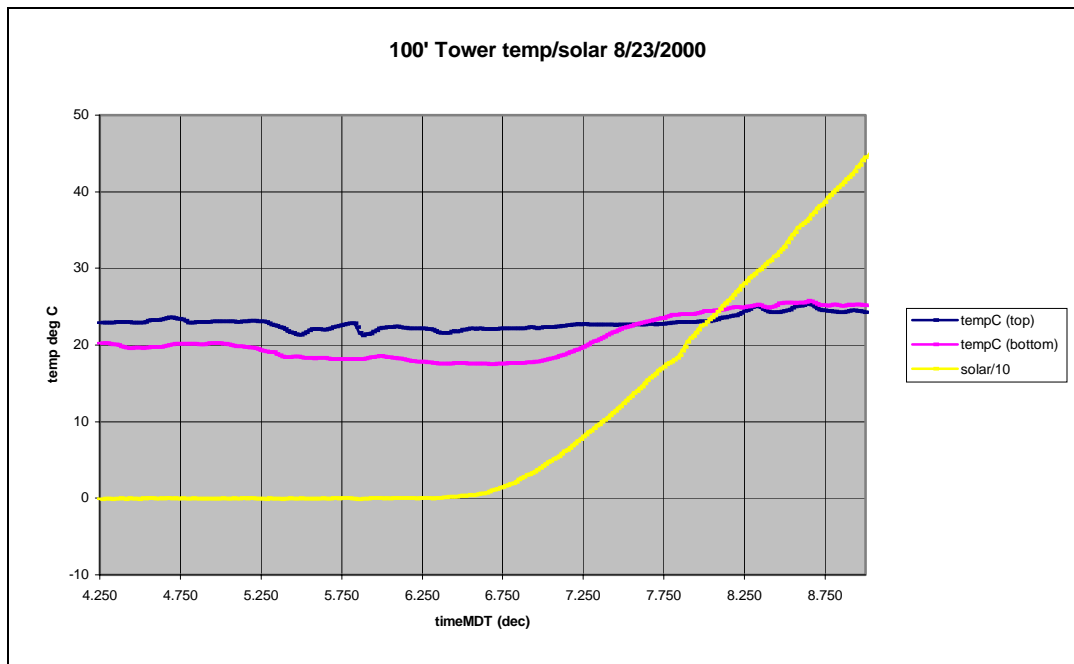


Figure B4. Tower temperature versus solar radiation, 8/23/2000.

Case 3

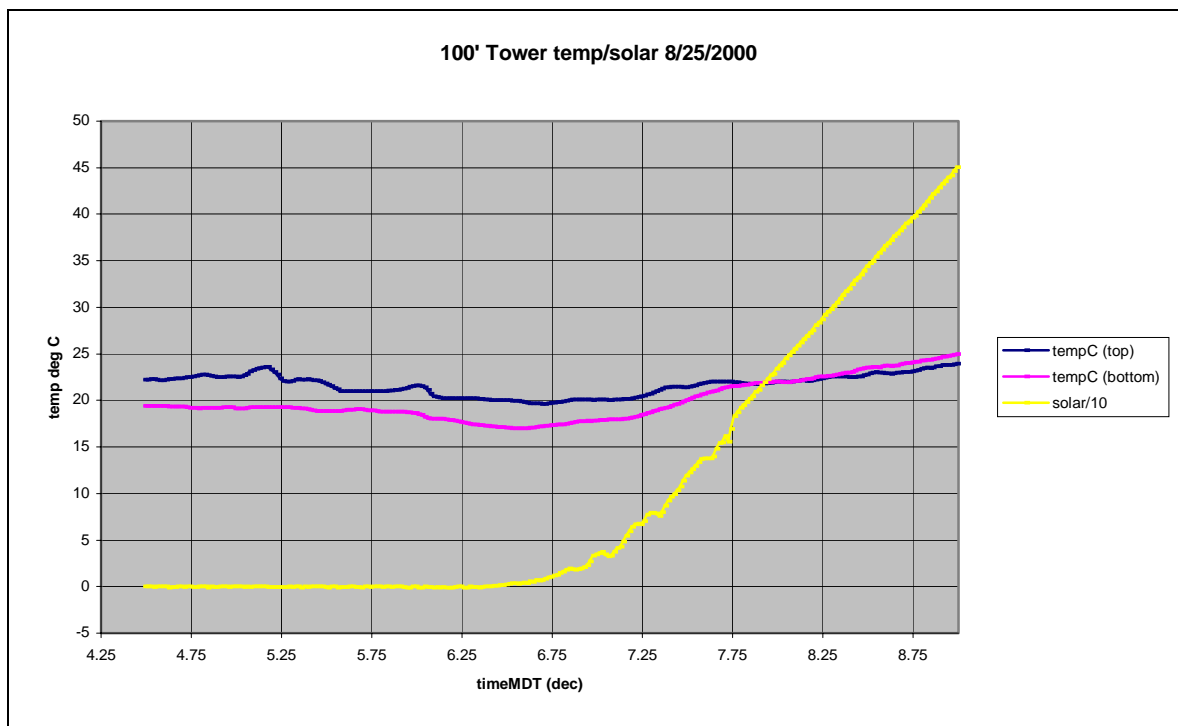


Figure B5. Tower temperature versus solar radiation, 08/25/2000.

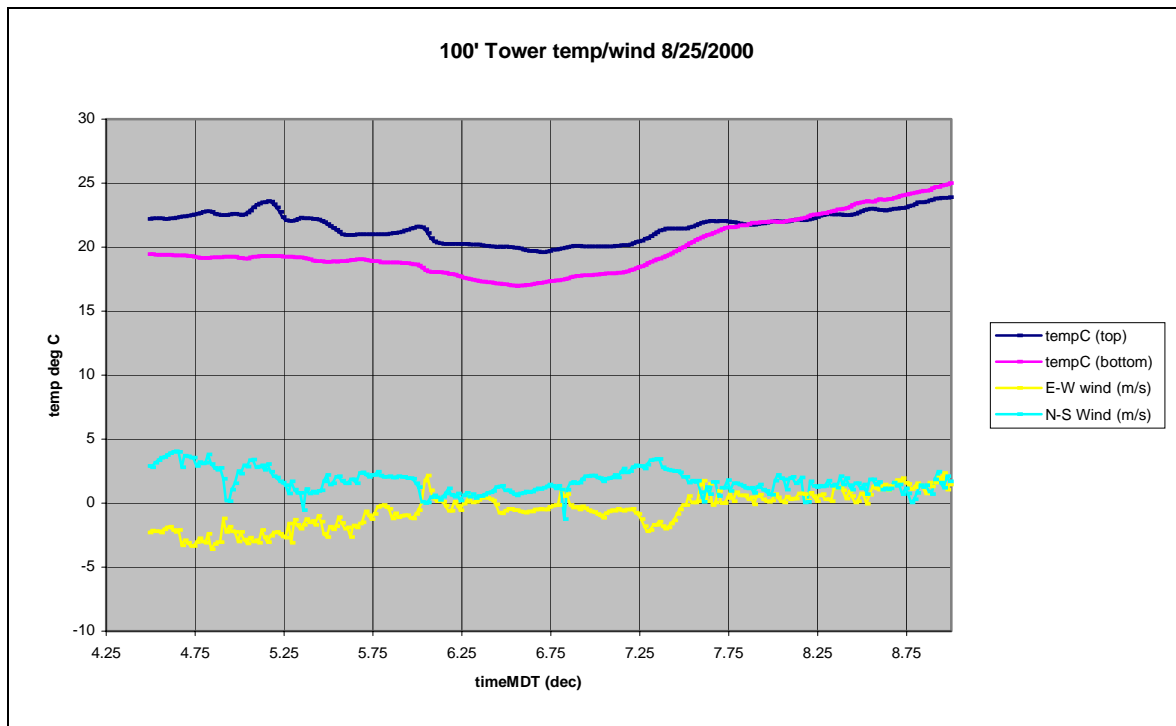


Figure B6. Tower temperature versus wind, 08/25/2000.

Appendix C- Sun Position (Elevation-Azimuth Angle) Tables (COMPASS¹) by Cases

Case 1

Table C1. Sun Angle data: at Sunrise (SR) and NE.

Sun	Elevation Angle (degree)	Azimuth Angle (degree)
SR	-0.15	76.28
NE	+15.08	86.25

Case 2

Table C2. Sun Angle data: at Sunrise and NE.

Sun	Elevation Angle (degree)	Azimuth Angle (degree)
SR	-0.20	76.65
NE	+11.47	83.99

Case 3

Table C3. Sun Angle data: at Sunrise and NE.

Sun	Elevation Angle (degree)	Azimuth Angle (degree)
SR	-0.36	77.37
NE	+14.56	86.72

¹ Algorithms based on *Quality Assurance Handbook for Air Pollution Measurements Systems, vol. IV: Meteorological Measurements* (as Revised March 1995) document number EPA/600/R-94/038d.

Acronyms

ASL	Atmospheric Surface Layer
Delta-T	The 35 m minus 2 m Temperature difference
DLR	Desert Lapse Rate Project
LR	Lapse Rate
MDT	Mountain Daylight Time
Met	Meteorology, meteorological
MSL	Mean Sea Level
NE	Neutral Event
SL	Surface Layer
SR	Sunrise
SRL	Sunrise, locally observed at the experiment site
T-RH	Temperature-Relative Humidity
WSMR	White Sands Missile Range